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ABSTRACT

Since computers were first introduced into early childhood educational settings, much debate has centered on the issue of appropriateness. This paper takes issue with a number of often cited reasons for not including computers in preschool, and advances a theoretical base for computer use in early childhood. The paper also offers a review of successful computer programs which includes a discussion of directions for software development. The first part of the paper takes up such issues as young children's capacity to learn from computer graphics, effects of computer use on children's social interactions and other activities, and the notion that young children must become programmers to use microcomputers. Next, the paper draws on theories of Piaget, Papert, and Erikson to explore the topics of computers as aids to thinking and tools that enable development, and computers and the instrumental competence model. Finally, the paper argues that learning in early childhood can be enhanced by discovery-oriented child-computer interactions, and advocates use of an expanded microworld format that relieves the child of programming requirements, but retains aspects essential to discovery-based learning. It is concluded that the microcomputer, when coupled with discovery-oriented microworld software, can empower young children's development. About 80 references are cited. (RH)

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Microcomputers in Preschool Environments: Answers to Questions, Theoretical Guidance and Future Directions

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Abstract

Over the years, since computers were first introduced to early childhood education, much debate and research has centered on the issue of appropriateness. In spite of recent gains in understanding, the debate rages on. The purpose of this article was threefold. First, research evidence was presented taking issue with a number of the most often cited reasons for not including computers in preschool environments. Secondly, a sound theoretical base for computer use in early childhood was developed which included: Piaget, Papert, Erikson, and competence development. Finally, direction for software development was offered through review and description of successful computer programs. It was concluded that the microcomputer, when coupled with discovery microworld software, has the potential to empower the development of young children.

Microcomputers in Preschool Environments: Answers to Questions, Theoretical Guidance and Future Directions

Technological development, application, and accessibility have produced a surge of interest among early childhood professionals and clients concerning the microcomputer's potential role in preschool education. The proliferation of personal computers from college courses to nursery schools and into the home prompted Kelman (1982) to bemoan the lack of time taken to reflect upon pedagogical, psychological, and ethical issues. Since Kelman's lament, proponents have arisen on both sides of the issue. Whereas some (Barnes & Hill, 1983; Cuffaro, 1984) warned that young children should not be involved with microcomputers, others (Ziajka, 1983) cautiously, albeit enthusiastically, argued otherwise. Since those early days a flurry of research has endeavored to address Kelman's concern. After nearly six years, what do we know about the appropriateness of computers as an educational media for young children? Do young children have the ability to learn from computers and what types of software are best suited to their cognitive, social, and emotional makeup. This paper will briefly review the concerns for which research has provided solid answers, present a theoretical foundation for the computer's inclusion in early childhood environments, and finally, give direction to early childhood software development.

Questions and Answers

When first made available to young children, computers elicited severe reactions from nearly every quarter of the early childhood field. The new technology's marvelous abilities were lost in the supposed threats to young children's development. Computers were described as powerful arcade games that would hypnotize young children and hold them against their will. As such it was predicted that computers in the early childhood classroom would mean the end of creativity, language, and motor development as interactions with classroom materials and people were displaced. Children were doomed to become social isolates as they spent large portions of their day in front of CRT screens. It was further pronounced that computers were unsuitable for 4,5, and 6 year old children because their current stage of cognitive development precluded operating a computer or learning from computer generated symbols. These and other concerns are addressed below.

1. Can Young Children Become Safe, Competent Computer Operators?

There is no longer any doubt that young children can operate microcomputer hardware. Numerous studies (Borgh & Dickson, 1983; Brinkley & Watson, 1986; Klinzing, 1985; Lipinski, Nida, Shade, & Watson, 1986; Muller, 1983; Shade, Nida, Lipinski, & Watson, 1986; Shade & Watson, 1987) have shown that young children can do the following: turn the computer on and off, remove and replace diskettes properly, follow instructions from picture menus, change disks as often as three times in a ten minute period, talk meaningfully about their

computer activity, work successfully in dyads, help one another, take turns, and share the computer.

2. Will Computer Use Reduce Children's Social Interactions and Displace Important Activities?

Another supposed threat to young children centered on the computer's assumed power to socially isolate children (Barnes & Hill, 1983) and displace important learning activities. Lipinski et al. (1986) recently completed a comprehensive replication study investigating the effects of microcomputers on the social behaviors and free-play choices of two groups of children, one full-day and the other half-day. Results indicated that just as many social behaviors occurred around the computer as in the other play areas with children rarely observed alone at the computer. In terms of displacement, although computer novelty initially interrupted free-play activity patterns by drawing children away from traditional fare such as finger-painting and block building, most activities returned to baseline levels within weeks. Others (Borgh & Dickson, 1983; Clements & Nastasi, 1985) support these findings.

3. Do Young Children Have the Capacity to Learn From Computer Graphics?

Many early critics of computer use by young children (Barnes & Hill, 1983; Cuffaro, 1984; Streibel, 1984) questioned children's ability to learn "abstract" concepts from a two-dimensional screen in spite of the fact that numerous studies have confirmed children's ability to comprehend information delivered via television (Collins, Wellman, Keniston, & Westby, 1978; Wright & Huston, 1981).

In an effort to deal with this criticism, Shade and Watson (1987) and Brinkley and Watson (1986) successfully taught three-year-olds to manipulate a fairly complicated sequence of single-key punches designed to sort screen graphics via an inside/outside scheme. Three-years-olds learned to sort objects correctly with as little as four 15-minute sessions while sitting in mother's lap (Shade & Watson, 1987) or six 15-minute sessions while being taught by an experimenter in various nursery schools (Brinkley & Watson, 1986). Both of these research teams recommended that age three be selected as an appropriate time for introducing a child to a microcomputer with discovery-based software.

4. What About Piaget, is it True That Young Children are in the Wrong Stage of Cognitive Development to use Computers?

Recently, Watson, Nida, and Shade (1986) took issue with the notion that children must reach the concrete operations stage before they are ready to work with a microcomputer. They stressed that the time had come for educators to apply cognitive theory to computers in early childhood education. Gelman and Baillargeon (1983) questioned the notion of broad stages of cognitive development, each characterized by qualitatively distinct structures. Research indicates that preschool children are not as egocentric as previously thought (Lempers, Flavell, & Flavell, 1977; Masangkay, McCluskey, McIntyre, Sims-Knight, Vaughn & Flavell, 1974), nor as perceptually limited in conservation tasks (Markman, 1979). They can distinguish between appearance and reality (Fein, 1979), and can follow the transformation of objects from one state to another (Gelman, Bullock & Meck, 1980). Further studies concluded that preoperational

children can often solve problems that require concrete operational structures (Karmiloff-Smith & Inhelder, 1975).

5. Does Technological Development Require More, Rather than less, Intellectual Development?

One popular criticism of microcomputer use by young children (Elkind, 1985, 1987a) seems to stem from a misconception about the characteristics of software available for young children. Elkind (1987a) has argued that it is simply a fact of technological development that the more highly developed a technology is, the more intellectual maturity is required in order to make safe use of it. Although it is true that some forms of high technology are unsafe for young children (automobiles, airplanes, and power tools), it is illogical to suggest that microcomputer use carries the same potential hazards. Certainly unregulated electronic media present potential hazards to young children's development. However, the danger to children comes from overexposure to poor quality programming, not from the nature of the activity itself. If the premise were true, that higher technology requires higher intelligence, then we should be witnessing a reverse of the present proliferation of computer usage. Fewer families would be purchasing home computers; not more (Anderson, 1984). It is simply a fact of technological development that as technology develops it becomes more accessible; easier to use. After all, how many of us really understand the technology behind our word processor or microwave oven? From this perspective, then, computers become more accessible to the young child as they become more technologically sophisticated.

6. Must Young Children Become Programmers in Order to use Microcomputers?

To some, the word 'computer' conjures up visions of computerized preschools where children sit for lengthy periods writing computer programs in basic or fortran. This notion comes from Elkind's (1987a) claim that one of the only two computer activities available to young children is programming. Truly, programming, as it occurs in the dungeons of IBM, is out of the young child's intellectual reach, and there is little doubt that LOGO commands, which require the input of distance or angle, are too abstract for the four- and five-year-old (Cuneo, 1985). However, one should not discount the pre-programming activities available through programs such as simplified Logo (Clements, 1984; Rosen, 1985) and Delta Drawing (Aronson, 1982). Using simple, single-keystroke commands young children can create a geometric design, print it, and take it home. This is a powerful experience that is centered more on the child's self-concept than intelligence quotient.

Davidson (in press) has illustrated how gross misconceptions of computer use by young children come about. According to Davidson, early childhood educators make second hand judgements based upon their own limited experience with computers. If an educator has "used a computer to search for data or tried to master the many procedures of a word processing program, the thought of children using computers may be mind boggling" (p. 11).

7. Is Most Microcomputer Software Designed for use with Young Children Merely Programmed Learning?

Although it is true that drill-and-practice software has dominated the early childhood software market, assuming drill to be the only computer activity available to young children is inaccurate. Children need not be subjected to programmed learning (Elkind, 1987a) to use microcomputers. Even from the earliest days, open-ended software has existed for children to use such as Color Me (Mindscape, 1985) or Magic Crayon (Clark, 1983), programs which allow children to make colorful screen designs and pictures with simple keyboarding. Recently the amount of open-ended software available to children and educators has begun to increase. Excellent examples are What Makes A Dinosaur Sore? (Heath, 1987) and The Bald-Headed Chicken (Heath, 1987); both of which allow children to create a story/picture by choosing animated figures to fill a background scene. The child can then edit his/her creation by changing figures, labeling figures, or writing a story about the picture. Guidelines, congruent in many ways with Piaget's principles of constructivism, are now available for evaluating the open-ended, discovery-oriented nature of preschool software (Haugland & Shade, 1988).

8. Can the Microcomputer be Considered a Valuable Early Educational Material, as are Blocks, Paints, and Crayons?

Aside from the obvious differences, the microcomputer can be viewed like any other material we utilize in early childhood education. Recently Haugland and Shade (1988) presented a developmental approach to the selection of software

since it is that, and the teacher (Clements, 1987), which determine how computers will function in the early classroom. Why should we single out this technology as potentially harmful when certainly television, picture-books, and even crayons can be implements of 'miseducation' (Elkind, 1987b)? There is nothing inherent in the computer that forces children to grow up too fast too soon. Like other early materials, computers are neither panacea nor pandemonium (Clements, 1987). When used appropriately, with discovery software and teacher guidance, computers can be more active than television (Hyson, 1985), less static than picture-books (Piestrup, 1985), and as open-ended as crayons (Watson et al. 1986). As a "symbolic machine" (Sheingold, 1986) the computer is not unlike activities such as "communicating with gestures, speaking, pretend play, counting, tapping a rhythm, singing, making a picture or a clay object," (p. 27). Furthermore, as a part of our everyday world,the computer is worthy of inclusion in the early childhood classroom as an object to explore, manipulate, and understand (Sheingold, 1986). If not, then all the electric typewriters, play telephones, and cash registers found in the dramatic play area should be removed. To say that the young children should be protected (Elkind, 1987a) from exposure to computers is tantamount to keeping the electric toothbrush under lock and key.

Prominent Theories of Development and Their Relationship to Preschool Computer Education: A Brief Expose'

As convincing as the above arguments may seem, they should not be taken at face value (see Clements, 1987; Goodwin, Goodwin, & Garel, 1986 for thorough reviews). What is required, before the computer can be accepted as 'just another educational tool (Watson, Nida, & Shade, 1986), is the development of a sound

theoretical foundation for their inclusion in early environments. No one would question the appropriateness of blocks or paints from a piagetian viewpoint. However the use of television and filmstrips in preschool education has little to offer the young child in terms of materials they can experience first hand. How then, does the computer bridge the gap between blocks and television? Can the computer, with all its wires and chips, function as blocks would? Is it open-ended enough for the young child to explore, manipulate, discover, and build intellectual structures? As a common part of the child's world, what does theory tell us to expect in terms of personality development or the development of competence? Much research will be required before definitive answers can be obtained for any of these questions but it behooves us to let theory guide our investigations. In light of this, the following section looks at early childhood computer education from several different theoretical perspectives.

Piaget/Papert: Computers as Objects With Which to Think

Piaget (1970) developed a model of children as constructivists; builders of their own intellectual structures. Without being taught children learn to speak, navigate through their environment (Papert, 1980a), and use informal mathematics (Piaget, 1970). Such "learning" involves the active exploration and consequent equilibration of the child's environment. In other words, the child is an active participant in the acquisition or construction of knowledge. Although a student of Piaget, Papert (1980a) differed in his interpretation of the prerequisites for cognitive development. Where Piaget stressed the complexity or formality of a concept, Papert stated that children simply lack appropriate materials with which to work. Our culture, he continued, supplies some materials in abundance and

some in relative poverty. For example, many things come in pairs (knives/forks, cups/saucers, shoes/socks). These natural pairs form the "materials" for learning an intuitive sense of number. Extrapolating from this Papert argued that developmental differences might be attributed to materials "missing" from the child's milieu.

Papert (1980a) referred to these missing materials as "objects-to-think-with" and outlined four important criteria. "Objects-to-think-with" must be: (1) Part of the natural landscape or embedded in the culture. (2) Part of the adult world and serve as a vehicle for relationships with adults. (3) Responsive to previous learning and accumulated knowledge. (4) Used to think about formal systems. Without spending precious limited space on examples such as blocks or pots and pans, we will turn immediately to the microcomputer as an object with which to think.

Computers are part of the natural landscape and culture; they are everywhere and in nearly every aspect of our lives. We awake to digital clocks, fix breakfast in a microwave, wear a quartz digital watch, drive to work in a car governed by computer logic, and process words. Many young children will soon be growing up as familiar with computer technology as they are currently with television and videotape. From their first day, they will observe parents and siblings word processing, playing videogames, managing information, and telecommunicating. Second, as mentioned before, computers are fast becoming prominent in the adult world. As a common part of our lives, whether boon or bane, computers have the potential to connect childhood and adulthood. In fact the computer compares favorably as a transitional object with many of the props (typewriters, cash registers) found in the dramatic play area. However, there is one exception – this one is real and it works. Countless times children have been

heard to exclaim with pride that they can work the "pu-ter" just like mommy and daddy (Shade et al, 1986). Third, computers, with appropriate software (Haugland & Shade, 1988), are responsive to the previous learning children bring with them. Software can be designed to capitalize on the capabilities of any developmental level and still be flexible enough for individual exploration and discovery (more on this latter). Fourth and final, computers can be used to think about formal systems such as language (Lawler, 1982a, 1982b), classification (Brinkley & Watson, 1986; Shade & Watson, 1987) and trajectory (Chaille & Littman, 1985). Just as gears and wheels bridged the concrete and formal during Papert's (1980) childhood and gave him something to relate mathematics to, computer simulations and discovery software can do the same for other concept areas.

Erikson: Computers As Tools to Enable Development

A second example useful to preschool practitioners and researchers comes from Erikson's theory of psychosocial development. Each of his stages (Erikson, 1950) are characterized by a developmental task or crisis. Successful resolution of each crisis empowers children to complete the next. and in this way development proceeds in a stepwise fashion. Three developmental tasks have special application to children and computers: autonomy, initiative, and industry.

Thomas (1979) defined autonomy as a growing sense of power through control. Papert (1980a) outlined the relationship of computers to autonomy when he noted that one of the most important by-products of child computer interactions was the mastery of a sophisticated piece of space-age technology. Research has documented (Borgh & Dickson, 1983; diRenzo, 1983; Hyson & Morris, 1985; Muller, 1983; Pearlman, 1976; Shade, Nida, Lipinski & Watson, 1986;

Shade & Watson, 1987) that preschool children between 18 and 60 months can master a variety of computer tasks. While interacting with computers children have been observed to say (Shade et al., 1986), "I did it, I did it, I made it work". It is not hard to imagine the powerful feelings resulting from successful computer experiences empowering the child and leading to an increased sense of autonomy.

With the successful development of autonomy comes a new challenge, establishing initiative. From toilet training and other self-mastery tasks the preschool child has learned that s/he has the ability to exercise control over some aspects of the environment. The logical desire is to discover all that the child can control. As the child continues to explore and master the physical and social environment initiative is increased (Fischer & Lazerson, 1984). Just as successful block and fingerpainting contributes to. the development of initiative, so does appropriate computer interaction. In fact, observations of children using computers (Shade, 1988) leads one to conclude that perhaps computers can enable the development of initiative like no other material before. Shy, backward children seem to come out of the woodwork after only limited exposure to computers.

With industry, the ability to master the skills necessary to compete and function successfully in society, we come to the crux of the matter. According to Erikson's theory (Erikson, 1950), this period (ages 7 to 12) constitutes the child's last opportunity to develop mastery over his or her environment in preparation for the enormously difficult tasks of identity and intimacy formation. For children who lived in an agricultural society the developmental tasks requisite for success were associated with farming. Likewise, for today's child caught in the middle of the technological revolution, the requisite skills are technological and computer related. Erikson (1950) further noted the importance of the surrounding social

contexts in the successful achievement of industry. If society supports the development of good educational opportunities and adequate models, a child's industry will be maximized. Therefore, adults are responsible for the appropriate introduction of computers into the lives of young children. We must see that computer use is geared to the child's developmental level and that it supports and enables the positive development of industry. "Enabling development" is what Papert (1980a) meant when he compared the Logo experience to a Samba school in Brazil. The Samba school is a cultural phenomenon supported by and participated in at every level of society. Learning to dance the Samba is as natural as learning to talk. Learning math in a Logo environment is as natural as learning French in France (Papert, 1980a). Mastering technology, according to Papert and our interpretation of Erikson, should come about in the same way.

Computers and the Instrumental Competence Model

The competence framework seems to be a logical extension of some of the best concepts taken from Piaget's and Erikson's theories. While definitions of competence vary to some degree, (Lange, Ladd, & Davis, 1982) there is increased consistency in what educational theorists and teachers believe to be important for enhanced early development and increased school achievement (Anderson & Messick, 1974; White, 1972).

According to Lange et al. (1982) competency includes not only the specific numerical, spatial, and linguistic abilities necessary for symbol manipulation, but just as importantly, an active, operative or instrumental disposition in examining the world. The competent child spontaneously takes objects apart and then tries to fix them, this transforms objects from one state to another to examine the

effects of his or her own manipulations. More specifically competent children (White, 1972): 1) use adults as resources for getting information about how objects work and events proceed, 2) note discrepancies among objects and events, 3) plan and carry out multi-step activities, and 4) attempt to make interesting associations between the objects and events encountered in the environment. Furthermore, these children are self-motivated and self-regulated. They are active not passive (Baumrind, 1971) and often are labeled "bright" or "smart" by their teachers (White, 1972). These children fit the description of "little scientists" illustrating the nature of children's interactions with the world.

"Little scientists are made rather than born," might be something White (1979), after many years of identifying caregiving behaviors essential to the development of competent children might say. He noted the need for children to have well designed environments, someone with which to consult, live language directed to them, access to many objects, exposure to diverse situations, demonstrations and explanations. Children also need interesting relationships pointed out, encouragement to complete tasks, and a feeling of self-worth. If we accept the assumption that it is good for children to develop the active disposition just described, then we must accept the goal of helping them to do so.

How might the computer aid the development of competence? As part of a well-designed environment, appropriate software could serve in a supporting role as *consultant* Microcomputers could be used to help children *explore diverse situations and object relationships* for which they lack skills. Sheingold (1986) suggested computers serve a "scaffolding" function much as when several children work to solve a problem that would incapacitate them individually (Doise, Mugny, & Perret-Clermont, 1975). Consider the examples given (Sheingold 1983) of children composing music without having to learn the complex notation

system (Brown, 1985) or creating stories (Quinn, Weinstein, & Schuyler, 1982) without writing skills. Imagine young children playing with a graphic block-building program that highlights, through television-like special effects, the relationships between size, shape, and balance (Sheingold, 1983). Microcomputers could be used to maximize children's natural exploratory behavior (Chaille & Littman, 1985) by *exposing them to hidden cause-and-effect relationships* that exist among objects and events. Very young children playing with a computer doll-house (Shade & Watson, 1987) could discover simple associations such as inside/outside.

Microcomputers could *encourage task completion* by combining visual, auditory, and kinetic feedback simultaneously. Such intense, immediate feedback helps strengthen the child's intrinsic motivation to learn (Lepper, 1985). Several researchers (Borgh & Dickson, 1983; Muller, 1983; Shade et al., 1986) have concluded that preschool children seem "drawn" to the computer for this reason. Furthermore, through the process of making choices and giving instructions to the computer, children can *develop a metacognitive awareness of causality* (Clements & Nastasi, 1985; Papert, 1980a). A young child programming a screen- or floor-turtle to draw a square finds out quickly that each action is followed by an immediate consequence. Immediate results serve to bind together the child's actions and their effects; something Seligman (1975) noted was essential in the prevention of "learned helplessness." However, programming is not the only way to gain these experiences. Graphic drawing (Clark, 1983) and music construction programs (Brown, 1985) can provide the same causal links between choice, action, and consequence

Microcomputers could help children to *connect different ways of knowing* (Sheingold, 1986) as when children use knowledge about their own body to debug

the turtle (Papert, 1980b), use procedural thinking to plan game (Tic Tac Toe) strategies or learn to jump rope (Lawler, 1985). These experiences help children to see familiar actions and objects in new ways. Lawler (1982a) indicated this when he discussed how playing with "Beachworld" changed his daughter's relationship to letters and words. During the process of playing on the computer, the twenty Beachworld words ceased to be abstract symbols and became tools for accomplishing a specific task. One could argue that seeing words as tools is something usually taken for granted or not learned until a later stage of cognitive development.

Discovery Microworlds: The Microcomputers Contribution to Early Childhood Education

Learning in early childhood situations can be enhanced by discovery oriented child-computer interactions. Such computer environments have been termed "microworlds" (Haugland & Shade, 1988; Lepper, 1985; Papert, 1980a) or simulations. Papert defined a microworld as:

> A subset of reality or a construct of reality whose structure matches that of a given cognitive mechanism so as to provide an environment where the latter can operate effectively. The concept leads to the inventing of microworlds so structured as to allow a human learner to exercise particular powerful ideas or intellectual skills (p. 204).

In other words, a microworld is an open-ended, teacher-designable, child-oriented, software experience where children have direct access to specific concepts as well as the ability to manipulate those concepts in meaningful ways. Of course when Papert (1980a) speaks of microworlds he is talking about Logo,

the turtle, and turtle-geometry. Taylor (1980) described this as the "tutee" mode. Through programming, or "teaching" the turtle what to do, children come into contact with their own thinking as well as with the geometry concepts hidden behind the attractiveness of the turtle.

A more expanded view of this software format relieves the child of programming but retains the interactive nature and child-in-control aspects essential to discovery based learning. This extended view of microworlds has recently been used in a number of studies with young children (Brinkley & Watson, 1986; Chaille & Littman, 1985; Lawler, 1982a, 1982b; Shade & Watson, 1987). Guidelines for evaluating software to determine appropriateness or microworld-like aspects (Haugland & Shade, 1988) have also been developed.

Lawler (1982a, 1982b) designed a microworld called "Beachworld" in which his three-year-old daughter could manipulate (through simple keyboard functions) twenty sprite or hyper-turtle graphics resembling a sun, car, and ball, etc. The child typed in the word "sun" from a 4x6 card and instantly a graphic sun would appear in the clouds above the beach. At first the child did not know the words and only knew a few letters, however, in three months she had learned to read the 20 words she had been using to create beach pictures. Furthermore, when tested by picking the same words off a printed page, she could read and relate their meaning.

This software format differs from the typical drill-and-practice method. The child's motivation to participate in the learning experience came from her enjoyment of the exploration process and chance to supply or invent the structure rather than master someone else's (Kerkman & Wright, 1984). In fact, microworld software or simulations (Lepper & Malone, 1985) have been credited with the ability to provide intellectually rich and intrinsically motivating learning

environments that maximize the conditions under which discovery learning should be expected to occur. These conditions (Lepper, 1985; Lepper & Malone, 1985; Malone, 1983; Malone & Lepper, 1985) include elements of the following characteristics of intrinsic motivation: challenge, curiosity, control, and fantasy. The *challenge* embedded in "Beachworld" was as follows. The goal of the activity, making a world, was personally meaningful and the outcome was relatively uncertain (Lawler's daughter started with essentially a blank screen). In addition, the feedback (instant visual and auditory response from screen objects) provided a sense of personal achievement and competence (Lawler, 1982b). Children have been observed expressing similar elation and personal pride when they interacted with other microworlds (Shade, 1986). Second, this software format gave Lawler's daughter the *control* to build a different Beachworld every time; much like blocks and sand. Kee (1981) expounded on the motivational aspects of control. If the child perceives him/herself to be the origin of behavior, he/she is said to be intrinsically motivated. If not, the child feels like a pawn and motivation becomes extrinsic. Third, the learning of letters and words was made incidental to *curiosity* about the Beachworld. In other words, rather than drilling the child this software capitalized on her natural tendencies to explore the world, make interesting associations and discover important concepts. Finally the entire activity was couched in a *fantasy* about the beach.

Shade and Watson (1987) recently used a microworld to teach three-year-old children to classify a unique array of objects (table, car, lamp, etc.) by the simple concept of inside/outside. Children, 18 to 42 months, spent a total of one hour manipulating graphic objects in and around the background scene of a house and yard. The children were randomly assigned to two groups; one received the inside/outside microworld and the other worked with software that drilled the

alphabet. Although there were no significant differences between the microworld and alphabet groups, the age by treatment interaction approached significance (p=.053). In other words, the mean number of real objects correctly classified on the post-test by three-year-olds in the microworld group was larger (8.27) than the alphabet three-year-olds (5.22). Post hoc power calculations (phi = 1.86, power = .53) revealed that a strong effect was present in the interaction and that significance was not reached because of the small sample size (n=10) in each group. In other words, this electronic houseplay enabled children as young as 36 months to construct knowledge necessary to correctly classify a series of real objects. Others (Brinkley & Watson, 1986) have replicated or performed similar research (Calvert, Watson, Brinkley, & Bordeaux, 1987; Watson, Calvert, & Popkin, 1986). In both of these studies microworlds evidenced significant potential for enhanced discovery-learning.

In support, Chaille and Littman (1985) cited the possibility that computer simulations (microworlds) could serve as "process highlighters" for young children. As such they can be used, in conjunction with related real-world, object-based activities, to expose "hidden processes" or cause-and-effect relationships, thus increasing the efficiency of the young child's natural hypothesis testing. Chaille and Littman used the pendulum as an example of a hidden process that traditional early childhood materials do not address. Since a real pendulum swings too rapidly for children to observe the trajectory, they are limited in their ability to engage in a level of theory building or knowledge construction which they might if conditions were otherwise.

With computer microworlds such as described above, virtually any concept, from the complexities of geometry to the simplicity of things that go inside or outside, could be modeled or simulated. Secondly, when children work with

microworld software, *they* are in control; *not* the computer; and the more sophisticated the microworld the greater the control. For example, Lawler's (1982a) daughter not only controlled what objects appeared in the Beachworld, she also controlled when objects appeared, how fast objects went, and in what direction. Third, microworlds are responsive to the child's previous experience and accumulated knowledge. Papert (1980b) and Lawler (1982b) noted the powerful learning that comes from bringing together knowledge gained in diverse experiences. The connection between past and present serves to make the experience personally meaningful to the child, a feature that distinguishes learning from labor. Papert's classic example of a child trying to draw a square or triangle with the Logo turtle illustrates this concept. If a "bug" occurred, the child could walk through the activity intended for the turtle (syntonic learning). Thus, knowledge of his/her own body and movement through space could be applied to the problem at hand. Finally, such software is accessible to preschool children because keyboard requirements can be minimized. Simplified versions of Logo requiring single key strokes are available for young children (Clements, 1984; Rosen, 1985). Three-by-five cue cards can also be used (Lawler, 1982b), or the keyboard can be covered with stickers that highlight the few keys necessary for software manipulation (Shade & Watson, 1987).

Conclusions

We have attempted to retire a number of ghosts haunting the early childhood professional who desires to include computer technology along with the playdough and blocks. We have tried to present the microcomputer as 'just another early childhood material' that can become a powerful, enabling tool when

coupled with appropriate software,. The microcomputer as a tool argument was approached from three major theoretical frameworks: Piaget/Papert, Erikson and competence development. By presenting microcomputers in light of these theories we echo Sheingold's (1986) plea for "software that is well designed for the young child, teachers who are willing to experiment with interesting uses for it in their classrooms, and researchers who can ask insightful questions about the learning that the technology affords (p.32)."

In conclusion, some thoughts from Jerome Bruner (1964) seem pertinent. Bruner stated that the intellect grows from the outside as well as the inside. In other words there are external, namely cultural, influences on cognitive development. Specifically, Bruner spoke of the influence a culture's technology has on adult thinking and functioning. In other words, he credited human advancement to interfacing with external amplifiers of motor, sensory, and logical reasoning rather than evolutionary changes. As Lange et al. (1982) pointed out, a child may not choose to work with highly technical equipment, but much of his/her adult life will still be affected by the presence of computer technology. Furthermore, Bruner (1964) stressed that the more complex a society becomes, the less time there is to teach children (or allow them to discover) all they need to become competent adults. According to Lange et al. this will require caregivers to "tell" children what the world is like and rely on the child's ability to ask the right questions. If correct, our major commitment to children will be to encourage an active disposition towards learning. If the microcomputer can help foster this development, it is time to accept it for the powerful tool it may become.

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